Description

[METHOD FOR PURCHASE ORDER RESCHEDULING IN A LINEAR PROGRAM]

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application is related to pending U.S. Patent Application 10/_____, filed concurrently herewith to Denton et al., entitled " A METHOD FOR SUPPLY CHAIN COMPRESSION" having (IBM) Docket No. BUR920030197US1; U.S. Patent Application 10/_____, filed concurrently herewith to Denton et al., entitled " A METHOD FOR SUPPLY CHAIN DECOMPOSITION" having (IBM) Docket No. BUR920040007US1; U.S. Patent Application 10/_____, filed concurrently herewith to Denton et al., entitled "A METHOD FOR OPTIMIZING FOUNDRY CAPACITY" having (IBM) Docket No. BUR920030195US1; U.S. Patent Application 10/_____, filed concurrently herewith to Denton et al., entitled "METHOD FOR FAIR SHARING LIMITED RESOURCES BETWEEN MULTIPLE CUSTOMERS" having (IBM) Docket No. BUR920040010US1; U.S. Patent Application

10/_____, filed concurrently herewith to Denton et al., entitled "A METHOD FOR CONSIDERING HIERARCHICAL PREEMPTIVE DEMAND PRIORITIES IN A SUPPLY CHAIN OPTIMIZATION MODEL" having (IBM) Docket No. BUR920030198US1; U.S. Patent Application 10/_____, filed concurrently herewith to Denton et al., entitled "METHOD FOR SIMULTANEOUSLY CONSIDERING CUSTOMER COMMIT DATES AND CUSTOMER REQUEST DATES" having (IBM) Docket No. BUR920040008US1; and U.S. Patent Application 10/_____, filed concurrently herewith to Orzell et al., entitled "METHOD FOR IDENTIFYING PRODUCT ASSETS IN A SUPPLY CHAIN USED TO SATISFY MULTIPLE CUSTOMER DEMANDS" having Docket No. BUR820030346US1. The foregoing applications are assigned to the present assignee, and are all incorporated herein by reference.

BACKGROUND OF INVENTION

[0002] *Field of the Invention*

[0003] The present invention relates to computer implementable decision support systems for rescheduling purchase order receipts. General methodologies within this field of study include advanced planning systems, optimization and heuristic based algorithms, constraint based program-

ming, and simulation.

Description of the Related Art

[0005] A fundamental problem faced in all manufacturing industries is the allocation of material and capacity assets to meet end customer demand. Production lead times necessitate the advance planning of production starts, inter-plant shipments, and material substitutions throughout the supply chain so that these decisions are coordinated with the end customers" demand for any of a wide range of finished products (typically on the order of thousands in semiconductor manufacturing). Such advance planning depends upon the availability of finite resources which include: finished goods inventory, work in process inventory (WIP) at various stages of the manufacturing system, and work-center capacity. Often, there are alternative possibilities for satisfying the demand. Products may be built at alternative locations and within a location there may be choices as to which materials or capacity to use to build the product. The product may be built directly or acquired through material substitution or purchase. When limited resources prevent the satisfaction of all demands, decisions need to be made as to which demand to satisfy and how to satisfy it. This resource allocation problem is often

addressed through linear programming.

[0006] The below-referenced U.S. Patents disclose embodiments that were satisfactory for the purposes for which they were intended. The disclosures of both the below-referenced prior U.S. Patents, in their entireties, are hereby expressly incorporated by reference into the present invention for purposes including, but not limited to, indicating the background of the present invention and illustrating the state of the art: U.S. Patent 5,971,585, "Best can do matching of assets with demand in micro-electronics manufacturing," October 26, 1999; U.S. Patent 5,943,484, "Advanced material requirements planning in microelectronics manufacturing," August 24, 1999; and Nemhauser, G.L. and Wolsey, L.A., 1999, Wiley, *Integer and Combinatorial Optimization* .

SUMMARY OF INVENTION

[0007] In view of the foregoing and other problems and draw-backs of conventional systems and methods, it is there-fore an object of the present invention to provide a method and system that tentatively (pre-processing) reschedules purchase order receipts into earlier time peri-ods, solves the resulting core production planning equa-tions using a linear programming solver, and subse-

quently (post-processing) reschedules the purchase order receipts to later time periods based on need. Thus, the invention moves the purchase order receipts into an earlier time period based upon frozen rules and a "net up front" indicator. The invention also creates recommended arrival times for the purchase order receipts that reflect the time of need, frozen zones, and tolerances. Further, the invention sorts the purchase order receipts based on a preferred sorting criteria and recomputes ending inventory to reflect the recommended rescheduling.

[0008]　More specifically, the invention provides a method of rescheduling timing of when items on purchase orders are scheduled to be received in a linear programming production planning system. This methodology performs a pre-processing rescheduling of the timing of purchase order receipts into the earliest time period allowable in a pre-processing step. After this pre- processing, the invention solves the core production planning system equations using the rescheduled purchase order receipts. Then, the invention performs post-processing rescheduling, which sorts the purchase order receipts according to rescheduling flexibility, and subsequently sequentially reschedules the timing of each of the purchase order receipts in the

order established by the sorting process. This process of sequentially rescheduling reschedules the timing of purchase order receipts into the latest time period allowable.

[0009] The pre-processing rescheduling of the timing of purchase order receipts is limited by flags associated with the purchase orders that either prevent the purchase order receipts from being rescheduled (according to frozen rules), or simply limit the extent to which the purchase order receipts can be rescheduled.

[0010] The sorting process first sorts the purchase order receipts into different classes of rescheduling flexibility. Then, the invention sorts the purchase order receipts within each of the classes of rescheduling flexibility into different classes of arrival dates and sorts the purchase order receipts within each of the classes of arrival dates based on quantities within the purchase orders.

[0011] The post-processing sequential rescheduling process reschedules the timing of each of the purchase order receipts into the latest time period before the corresponding inventory level would be depleted to zero. If the purchase order receipt timing can be extended beyond the latest date of the planning horizon of the linear programming production planning system, the purchase order can be

eliminated. The invention also recomputes ending inventory levels to reflect the sequential rescheduling of the timing of purchase order receipts.

[0012] Thus, invention described below reschedules purchase order receipts in a context where a linear program (LP) is employed to provide the vast majority of the core decision making technology in determining a production plan. The invention works through pre-processing prior to the LP run and post-processing after the LP run. During a pre-processing step, purchase orders (POs) are pulled into the earliest time period permissible according to the "frozen rules." In a post-processing step, a heuristic algorithm pushes the POs out to the latest time period which avoids a worsening of customer service and honors the "frozen rules." This post-processing is accomplished by examining inventory balances as a function of purchase order movements and ensuring the inventory balances do not drop below zero throughout the planning horizon. As a result, this invention enables the improved control of inventory of purchased parts when an LP is the core decision technology in creating the production plan.

BRIEF DESCRIPTION OF DRAWINGS

[0013] Figure 1: Overview of the structure of a linear program-

ming application.

[0014] Figure 2: Summary of pre-processor logic.

[0015] Figure 3: Summary of post-processor logic.

[0016] Figure 4: Summary of post-processor sorting logic.

[0017] Figure 5: Summary of the logic for determining recommended arrival dates.

DETAILED DESCRIPTION

[0018] Detailed Description of Preferred Embodiment(s) of the Invention

[0019] The invention disclosed comprises a method for achieving the rescheduling of purchase order receipts. The system and method were employed to integrate the consideration of purchase order rescheduling with a linear programming based system for optimizing established planning objectives (e.g. customer service, short lead times, low inventory, and prioritized allocation of supply and capacity) to compute a feasible production plan.

[0020] Line items on purchase orders are sometimes referred to herein as "purchase order receipts." The invention reschedules the timing of when purchase order receipts are scheduled to be received (which is sometimes referred to herein as "receipt period") in a linear programming

production planning system to maximize efficiency and minimize the cost of inventory. A purchase order is generally for a single part number, but sometimes it is for multiple part numbers. For each part number, a purchase order may have multiple line items associated with different requested delivery dates and different committed delivery dates. Each line item would be considered a "purchase order receipt." Often a purchase order would have a single line item, but not always. This methodology initially artificially reschedules the timing of purchase order receipts into the earliest time period allowable in a pre-processing step. After this pre-processing, the invention solves the core production planning system equations using the rescheduled purchase order receipts and subsequently reverses this artificial rescheduling in a post-processing rescheduling process.

[0021] Therefore, with the invention, the conventional core production planning equations and limitations are calculated assuming that all items on almost all purchase orders are received at the very beginning of the production planning horizon. In other words, this allows the invention to ignore various purchase order receipt timing issues (except for purchase order receipts that are frozen or have spe-

cific timing restrictions, as discussed in greater detail below) to most efficiently allocate different resources and different planning requirements within the production planning system. After the core production planning process is completed, the timing of the purchase order receipts is rescheduled so that this artificial timing advancement limitation (which permitted artificial maximum flexibility within the production planning system) is eliminated. By reversing the artificial advancements of timing of purchase order receipts, the invention pushes the actual timing of purchase order receipts back as far as possible within the production planning horizon so as to minimize costs associated with maintaining an excessively large inventory.

[0022]   The post-processing pushes the timing of the purchase order receipts back to the latest allowable periods within the production planning system by sorting the purchase order receipts according to their rescheduling flexibility. The invention then subsequently reschedules (e.g., sequentially reschedules) the timing of each of the purchase order receipts in the order established by the sorting process. This post-processing process reschedules the timing of purchase order receipts into the latest time period al-

lowable, again, to minimize the cost of inventory.

[0023] To contrast the present invention, a conventional production planning linear program "LP" is shown below (such as that described in U.S. Patent 5,971,585, which is incorporated herein by reference). This LP makes decisions including: production starts, material substitutions, and shipments planned to customers, between manufacturing and distribution locations, and from vendor suppliers. A LP is composed of an objective function that defines a measure of the quality of a given solution, and a set of linear constraints. The types of equations used in production planning models are well know to those practiced in the art and include:(1) Material Balance Constraints, which ensure conservation of material flow through the network of stocking points comprising the supply chain.

[0024] (2) Capacity Constraints, which ensure that the capacity available for manufacturing activities is not exceeded.

[0025] (3) Backorder Conservation Constraints, which balance the quantity of a given part backordered in a given planning period with the quantity backordered in the previous planning period and the net of new demand and new shipments.

[0026] (4) Sourcing Constraints, which define target ranges

(minimum and maximum) of shipments that should be made from a particular manufacturing or vendor location in the supply chain.

[0027] A conventional LP formulation is provided below in the form familiar to those practiced in the art; i.e., definition of subscripts, definition of objective function coefficients, definition of constants, definition of decision variables, LP formulation or equations.

[0028] *Definition of Subscripts*

[0029] j – time period

[0030] m – material (part number)

[0031] a – plant location within the enterprise

[0032] n – material being substituted

[0033] z – group (which represents a family or collection of part numbers)

[0034] e – process (a method of purchasing or manufacturing a material at a plant)

[0035] v – receiving plant location

[0036] k – demand center (i.e., customer location) (Note: the set of customer locations is mutuallyexclusive from the set of plant locations)

[0037] q – demand class which indicates relative priority

[0038] w – resource capacity which could be a machine, labor hour, or other constraint

[0039] u – represents a consumer location which refers to an internal plant, external demand center, or toa generic indicator meaning any plant/or demand center

[0040] *Definition of Objective Function Coefficients*

[0041] PRC_{jmae} – cost of releasing one piece of part m during period j at plant a using process e

[0042] $SUBC_{jmna}$ – substitution cost per piece of part number n which is being substituted by part number m during period j at plant a

[0043] TC_{jmav} – transportation cost per piece of part number m leaving plant a during period j which are destined for plant v

[0044] $INVC_{jma}$ – inventory cost of holding one piece of part number m at the end of period j at a particular plant a

[0045] $DMAXC_{jzau}$ – cost per piece of exceeding the maximum amount of shipments of group z parts from plant a to consuming location(s) u during period j

[0046] $DMINC_{jzau}$ – cost per piece of falling short of the minimum amount of shipments specified for group z parts from

plant a to consuming location(s) u during period j

[0047] BOC_{jmkq} – backorder cost of one piece of part m at the end of period j for class q demand at customer location k

[0048] *Definition of Constants*

[0049] $DEMAND_{jmkq}$ demand requested during time period j for part number m at customer location k for demand class q

[0050] $RECEIPT_{jma}$ – quantity of projected wip and purchase order receipts for part number m expected to be received at plant a during time period j

[0051] $CAPACITY_{jaw}$ – Capacity of resource w available at plant a during period j to support production starts

[0052] $CAPREQ_{jmaew}$ – Capacity of resource w required for part number m at plant a for process e during period j

[0053] $QTYPER_{jmaen}$ – quantity of component m needed per part number n during period j at plant a using process e

[0054] $YIELD_{jmae}$ – output of part number m per piece released or started at plant a during time period j using process e

[0055] $SUBQTY_{jmna}$ quantity of part number m required to substitute for one piece of part number n at plant a during time period j

[0056] $MAXPCT_{jzau}$ – maximum percentage of total shipments of group z (collection of parts) leaving supplier a during period j to support consumption at consuming location(s) u

[0057] MINPCT_{jzau} – minimum percentage of total shipments of group z (collection of parts) leaving supplier a during period j to support consumption at consuming location(s) u

[0058] CT_{jmae} – Cycle time. The number of periods between the release and completion of part m jobs for releases made using process e at plant a during time period j

[0059] TT_{mav} – transport time for part number m from plant a to plant v

[0060] *Definition of LP Decision Variables*

[0061] I_{jma} – Inventory at the end of period j for part number m at a particular plant a

[0062] P_{jmae} – Production starts of part m during period j at plant a using process e

[0063] L_{jmna} –Quantity of part number n which is being substituted by part number m during period j at plant a

[0064] T_{jmav} – Internal shipments of part number m leaving plant a during period j which are destined for plant v

[0065] F_{jmakq} – Shipments of part number m leaving plant a during period j and satisfying class q demand at external customer k

[0066] B_{jmkq} – Back orders of part m at the end of period j for class q demand at customer location k

[0067] H_{jzu} – Total shipments of group z (z is a "collection" of

parts) leaving suppliers during period j to support consumption at consuming location(s) u

[0068] S_{jzau} – Amount by which total shipments of parts in z from plant a to consuming location(s) u during period j exceeds the maximum amount specified as desired in the sourcing rules

[0069] G_{jzau} – Amount by which total shipments of group z parts from plant a to consuming location(s) u during period j falls short of the minimum amount specified as desired in the sourcing rules

[0070]   *LP Equations or Formulation*

[0071]   The following minimizes the objective function subject to the constraints shown below.

[0072]   *Objective Function:*

[0073]   Minimize:

$$\sum_{j}\sum_{m}\sum_{a}\sum_{e} PRC_{jmae} P_{jmae} + \sum_{j}\sum_{m}\sum_{n}\sum_{a} SUBC_{jmna} L_{jmna} + \sum_{j}\sum_{m}\sum_{a}\sum_{v} TC_{jmav} T_{jmav} +$$
$$\sum_{j}\sum_{m}\sum_{a} INVC_{jma} I_{jma} + \sum_{j}\sum_{z}\sum_{a}\sum_{u} DMAXC_{jzau} S_{jzau} + \sum_{j}\sum_{z}\sum_{a}\sum_{u} DMINC_{jzau} G_{jzau} +$$
$$+ \sum_{j}\sum_{m}\sum_{k}\sum_{q} BOC_{jmkq} B_{jmkq}$$

[0074]   *Subject to:*

[0075]   Sourcing Constraints:

$$H_{jzu} = \sum_{\substack{m \\ \varepsilon z}} \sum_{a} (T_{jmau} + \sum_{q} F_{jmauq})$$

$$\sum_{\substack{m \\ \varepsilon z}} (T_{jmau} + \sum_{q} F_{jmauq}) - S_{jzau} \leq MAXPCT_{jzau} \ H_{jzu}$$

$$\sum_{\substack{m \\ \varepsilon z}} (T_{jmau} + \sum_{q} F_{jmauq}) + G_{jzau} \geq MINPCT_{jzau} \ H_{jzu}$$

[0076] Capacity Constraints:

$$\sum_{m} \sum_{e} CAPREQ_{jmaew} P_{jmae} \leq CAPACITY_{jaw}$$

[0077] Backorder Constraints:

$$B_{jmkq} = B_{(j-1)mkq} + DEMAND_{jmkq} - \sum_{a} F_{jmakq}$$

[0078] Material Balance Constraints:

$$I_{jma} = I_{(j-1)ma} + RECEIPT_{jma} + \sum_{\substack{xsi.t \\ x+CT_{xmae}=j}} \sum_{e} YIELD_{xmae} * P_{xmae} + \sum_{n} L_{jmna} +$$

$$\sum_{\substack{xs.t \\ x+TT_{mav}=j}} \sum_{v} T_{xmva} - \sum_{n} SUBQTY_{jmna} * L_{jmna} - \sum_{v} T_{jmav} - \sum_{k} \sum_{q} F_{jmakq}$$

$$- \sum_{\substack{nst.m \\ is a component \\ of n}} \sum_{e} QTYPER_{jmaen} P_{jnae}$$

[0079] Non-Negativity Constraints:

all $X_{i,j...} \geq 0$, where X is a generic decision variable and i, j etc. represent generic subscripts.

[0080] Linear programs have been used to determine production plans for many years (see, for instance, U.S. patent 5,971,585). However, these linear programming applications have considered purchase orders as a fixed input to the application rather than as something which could be

changed. In other words, the conventional linear programs did not reschedule purchase orders. The conventional purchase order rescheduling has been limited to Material Requirements Planning (MRP) systems (e.g. U.S. Patent 5,943,484) which is a fundamentally different art field that the production planning art field. Further, this conventional MRP rescheduling has only been based on when the ordering plant needs the parts and "frozen rules." This prevents MRP rescheduling in the near term when the vendor may not have time to adjust delivery. Further, this rescheduling has only been accomplished within the context of heuristic based MRP calculations and not within linear programming.

[0081] Linear programming applications typically include the transformation of input files (block 100) into output files (block 108) through a pre-processor (block 102), solver (block 104), and post-processor (block 106) as shown in Figure 1. The pre-processor (block 102) transforms the raw input files into a form useable by the linear programming solver. The solver (block 104) determines an optimal raw output solution which is transformed by the post-processor (block 106) into a format acceptable for usage. The present invention is embedded in the pre-processor

(block 102) and post-processor (block 106) stages and is used to provide purchase order rescheduling.

[0082] One of the activities contained within the pre-processor (block 102) is the transformation of a raw input planned receipt file into a file which contains the projected WIP and purchase order receipts quantity expected to be received for each part number at each receiving plant during each time period. Conventionally, purchase order receipts are placed into the time period when they are currently expected to be received.

[0083] In one preferred embodiment, the logic for determining the period in which the purchase order receipt is placed is summarized in Figure 2. It will be recognized by those skilled in the art that references to "purchase order / purchase order receipt" may also refer to purchase order line items or other agreements with vendors such as scheduling agreements, supply agreements, etc. In block 202, the invention checks to see if the particular receipt has a "net up front" flag which indicates whether or not it may be moved into an earlier time period than its present scheduled arrival date. If the receipt may be moved in, block 204 checks to see if there is a frozen-in zone flag or rule which limits the extent to which the receipt may be moved

in. If there is no such frozen-in zone, then block 208 sets the receipt period to the first period of the planning horizon. Otherwise, block 206 will set the receipt period to the earliest period which is not earlier than implied by the frozen-in zone. In other words, the receipt period will be set to the earliest period during which the supplier will allow to the orderer to move it.

[0084] The result of this pre-processing is that the core solver (block 104) will be utilizing the purchase order receipts as if available in the earliest possible period, i.e., the planned start date. Subsequent to the core solver's execution, the post-processing steps will push the receipts out to the latest dates when they are needed and permissible according to the agreements with the suppliers. The post-processor steps unique to the invention are summarized in Figure 3. The post-processor steps referenced in block 106 refer to these Figure 3 steps included in this invention in addition to the post-processor steps required to transform the core solver output into a format acceptable for usage.

[0085] In block 302, the purchase order receipts are sorted. There are a number of reasonable ways to sort the purchase order receipts. The sorting of one preferred em-

bodiment is summarized in Figure 4. Block 402 establishes the primary sorting criteria which is based on the flexibility to reschedule out. Some purchase order receipts may not be rescheduled later in time because they are within the "frozen out" zone. That is, they are within the period of time during which the orderer does not have the freedom or flexibility to reschedule later in time. These frozen out zones are typically established to allow the supplier time to build in advance without fear of having purchase order cancellations/delays result in excess and/or unsold inventory. Consequently, block 402 sequences purchase order receipts which may be rescheduled out at the beginning of the purchase order receipt list and those which may not be rescheduled out at the end of the purchase order receipt list.

[0086] Blocks 404 and 406 establish secondary and tertiary sorting criteria respectively. In block 404, the sub-sorting is performed in sequence of increasing scheduled arrival dates. This is done to preferentially consider the most imminent portion of the planning horizon first. Finally, block 406 establishes the final (and least important) sorting criteria by sub-sorting in sequence of decreasing quantities.

[0087] Block 304 determines the "need dates" of the purchase

order receipts. These are the dates that the purchase order receipts are needed to arrive to stock at the receiving location. Block 304 processes the purchase order receipts according to the sort sequence specified in block 302. For each purchase order receipt, block 304 pushes the receipt out in time into the latest time period which does not result in a negative inventory situation. Step 304 is an iterative step in which the timing of the purchase order receipt is moved out into successively later periods and material balance equations are rebalanced at each iteration. If there are no such periods in which the inventory variable becomes negative then this is an indication that the purchase order receipt is not needed. In this case, the purchase order receipt is flagged as "not needed." The resulting iterative modifications to inventory in each time period is maintained in memory.

[0088] Block 306 determines recommended arrival dates for the purchase order receipts. The recommended arrival dates are often the same as the need dates of the purchase order receipts but may be different due to contractual agreements or a desire to avoid the introduction of trivial rescheduling changes. The logic of block 306 is summarized in Figure 5. In block 502, the recommended arrival

date is initialized to the original scheduled arrival date. The remaining blocks of Figure 5 determine whether the purchase order receipt needs to be rescheduled. Block 504 examines whether the need date determined by block 304 is earlier than the original scheduled arrival date. If the need date is earlier, block 506 checks to see whether it is earlier by more than the required tolerance. If it is, then block 508 will set the purchase order receipt's recommended arrival date to the need date. If block 504 determines that the need date is later than the original scheduled arrival date, then block 510 checks to see whether the receipt's scheduled receipt date is within the frozen zone. If is not within the frozen zone, then it is contractually permissible for the orderer to reschedule the purchase order receipt. If the receipt is not within the frozen zone, block 512 will check whether the need date is later than the scheduled arrival date by more than the required tolerance. If it is, block 508 will set the purchase order receipt's recommended arrival date to the need date. The value of the tolerance used in block 506 may or may not be different than the value of the tolerance used in block 512. The general idea of the tolerance is to avoid unimportant schedule churn.

[0089] In block 308, ending inventory balances are recomputed under the assumption that the recommended arrival dates are the dates when the purchase order receipts will arrive at the receiving plant. This re-computation is necessary if the period ending inventory is an important output of the production plan. In such cases, the re-computation is performed for all purchase order receipts for those time periods between the recommended receipt date inclusive and the original scheduled receipt date inclusive.

[0090] Following is a pseudo code description of one example of the current invention:

[0091] Definitions:

[0092] FROZEN_IN: This number of days beyond the PLANDATE denotes the earliest date to which the can be rescheduled to (i.e. order can"t be moved earlier than PLANDATE + FROZEN_IN)

[0093] FROZEN_OUT: This number of days beyond the PLANDATE denotes the date such that orders prior to this date can-not be rescheduled out

[0094] NET_UP_FRONT: yes/no flag indicating whether the pur-chase order receipt can be rescheduled to an earlier date

[0095] ORIGINAL_PROJECTED_DATE: originally scheduled arrival date for a particular purchase order receipt arrival

[0096] PLAN_START_DATE: first date in the planning horizon

[0097] PLAN_END_DATE: last date in the planning horizon

[0098] NEED_DATE: date on which some of the quantity for a particular purchase order receipt are utilized for manufacturing

[0099] RECOMMMENDED_DATE: rescheduled date for the purchase order receipt recommended by the application of the rescheduling method

[0100] PURCHASE: set of purchase order receipt records for arrival of parts to specified stocking locations

[0101] CANCELLATION_FLAG = yes/no flag indicating whether the purchase order receipt can be cancelled

[0102] MIN_RESCHEDULE_IN: Tolerance measured in number of days. If the need date is not more than this tolerance from the ORIGINAL_PROJ_DATE then do not reschedule (i.e. avoid trivial rescheduling changes)

[0103] PN: part number

[0104] PLANT: manufacturing location

[0105] Step 1: For (all purchase order receipts in PURCHASE for which the NET_UP_FRONT flag is set to "yes"){

[0106] Save the original projected date in ORIGINAL_PROJ_DATE for use in Step 5

[0107] Set the new projected date for the purchase order receipt to PLANDATE +

[0108] FROZEN_IN

[0109] }

[0110] Save purchase order receipts (with new projected dates) to PURCHASE

[0111] Step 2: Create and solve an instance of the LP model using revised PURCHASE created in Step 1

[0112] Step 3: Sort records in PURCHASE according to a preferred ordering (e.g. from earliest to latest date)

[0113] Step 4: Using the LP solution from step 2 Compute NEED_DATE for all purchase order receipts in PURCHASE:

[0114] For (all purchase order receipts in PURCHASE){

[0115] Compute NEED_DATE:

[0116] a) Iteratively move the purchase order receipt out in the planning horizon one period at a time.

[0117] b) For each move out recompute material balance equations throughout the planning horizon (current date to PLAN_END_DATE)

[0118] c) If inventory drops below zero for any period in planning horizon back up to previous period (This period is the NEED_DATE). If the PLAN_END_DATE is reached then it is

the NEED_DATE

[0119] }Step 5: Compute RECOMMEND_DATE for all purchase order receipts in PURCHASE:

[0120] For (all purchase order receipts in PURCHASE){

[0121] if (ORIGINAL_PROJ_DATE > (PLAN_START_DATE _+ FROZEN_OUT_DATE)){

[0122] if((ORIGINAL_PROJ_DATE NEED_DATE) > 0 && (PROJ_DATE NEED_DATE) <= MIN_RESCHEDULE_IN){

[0123] RECOMMENDED_DATE=ORIGINAL_PROJ_DATE

[0124] }

[0125] else RECOMMENDED_DATE=NEED_DATE

[0126] if(RECOMMENDED_DATE>END_DATE) set CANCELLA-TION_FLAG="yes"

[0127] }

[0128] }

[0129] Step 6: Iteratively recompute inventory based on RECOM-MENDED_DATE and save for final output of solution:

[0130] For (all purchase order receipts in PURCHASE){

[0131] Recomputed inventory variables for the relevant PN/ PLANT for all periods between PROJ_DATE and RECOM-MENDED_DATE to rebalance inventory equations

[0132] }

[0133] The present invention has been implemented on an IBM P690 server using the AIX operating system. The steps for implementing the present invention are preferably programmed in C/C++. It should be understood by those of ordinary skill in the art, however, that the present invention is not limited to the above implementation and is independent of the computer/system architecture. Accordingly, the present invention may equally be implemented on other computing platforms, programming languages and operating systems, and also may be hardwired into a circuit or other computational component.

[0134] Thus, as shown above, the invention reschedules the timing of when items on purchase orders are scheduled to be received in a linear programming production planning system to maximize efficiency and minimize the cost of inventory. This methodology initially artificially reschedules the timing of purchase order receipts into the earliest time period allowable in a pre-processing step. After this pre-processing, the invention solves the core production planning system equations using the rescheduled purchase order receipts and subsequently reverses this artificial rescheduling in a post-processing rescheduling pro-

cess.

[0135] Therefore, with the invention, the conventional core production planning equations and limitations are calculated assuming that all items on almost all purchase orders are received at the very beginning of the production planning horizon. In other words, this allows the invention to ignore various purchase order receipt timing issues (except for purchase order receipts that are frozen or have specific timing restrictions, as discussed in greater detail below) to most efficiently allocate different resources and different planning requirements within the production planning system. After the core production planning process is completed, the timing of the purchase order receipts is rescheduled (post-processing) so that this artificial timing advancement limitation (which permitted artificial maximum flexibility within the production planning system) is eliminated. By reversing the artificial advancements of timing of purchase order receipts in the post-processing, the invention pushes the actual timing of purchase order receipts back as far as possible within the production planning horizon so as to minimize costs associated with maintaining an excessively large inventory.

[0136] The post-processing pushes the timing of the purchase

order receipts back to the latest allowable periods within the production planning system by sorting the purchase order receipts according to their rescheduling flexibility. The invention then subsequently reschedules (e.g., sequentially reschedules) the timing of each of the purchase order receipts in the order established by the sorting process. This post-processing reschedules the timing of purchase order receipts into the latest time period allowable, again, to minimize the cost of inventory.

[0137] While the invention has been described in terms of the preferred embodiments, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the appended claims.